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Factors related to mild cognitive impairment among type 2 diabetic patients attending Diabetes Center in Al-Madinah, Saudi Arabia 2019-2020

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General Note

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ABSTRACT

Background: Diabetes mellitus is a world-wide impact, it affect many organs and systems. Mild cognitive impairment is a well-known phenomena in elderly. *Objectives:* The objectives of this study are to improve health of type 2 diabetes mellitus patients in Al-Madinah City in concern of their mental health and improving their CNS function and cognition and to determine the prevalence of mild cognitive impairment among type 2 diabetic patients attending Diabetes Center in Al-Madinah City in 2019. In addition, identifying possible risk factors of mild cognitive impairment among the studied diabetic patients. *Subjects and Methods:* This is a cross-sectional study. The present study conducted at outpatient clinics in the diabetic center of Al Madinah. This is the largest diabetic center in Al_MadinahAlMunawara region and serves the city and most of the nearby cities. The diabetic patients are attending the center for treatment and follow up. The study was taking about 12 months from the mid 2019 till the mid 2020. All type 2 diabetic patients attending the diabetes center during the period of the study were eligible to be included in the present study. The data collection tools were two questionnaires. The first one is general and structured questionnaire designed with special emphasis on general demographics and risk factors of MCI. The second one was the Montreal Cognitive Assessment (MoCA). *Result:* The mean age of the studied patients was 52.2 ± 7.5 years with 59% participants aged 50 and more years, and male patients were representing 71% of the studied patients. Of the studied 200 patients there have been 118 (59%) patients showed normal cognitive function. Forty-eight patients (24%) were found to have mild cognitive impairment, 15% showed moderate and 2% showed severe impairment. The pie chart showed the frequency distribution and percentage of the cognitive impairment among the studied diabetic patients. Hypertensive patients were only showed a significant higher prevalence of mild cognitive impairment (34% vs. 21.2%). Although not significant the prevalence was also higher among patients with heart (38.4%) and CNS diseases (33.3%). *Conclusion:* There was considerable increment of MCI among type 2 diabetic patients. Certain factors appeared to be at a higher risk of MCI and was found to increase the prevalence among the studied diabetic patients. patients' age, sex, marital status, educational level and occupation are amongst the socio-demographic factors. Also, the diabetes duration, compliance to treatment, HbA1c level and type of medication as well as the associated heart disease and hypertension were included.

Keywords: Type 2 diabetes mellitus (T2DM), dementia, mild cognitive impairment (MCI)

1. INTRODUCTION

Diabetes mellitus (DM) is a global disease that afflicts nearly 382 million people worldwide. Three-fourths of all patients with diabetes live in China, India, and the USA. The World Health Organization (WHO) has considered Saudi Arabia as the second highest rate of diabetes in the Middle East (7th highest in the world) with an estimated population of7 million living with diabetes and more than 3 million with pre-diabetes (Roy et al., 2015).

The most common type of DM is type 2 and characterized by disorders of insulin action and insulin secretion, either of which may be the predominant feature. Both are usually present at the time that this form of diabetes is clinically manifest (World Health Organization 2016).

Type 2 DM is a term used for individuals who have relative, rather than, absolute insulin deficiency. This type of diabetes is frequently undiagnosed for many years because the hyperglycemia is often not enough to provoke symptoms of DM (World Health Organization 2016). While type 2 diabetes mellitus has been associated with coronary artery disease, hypertension, renal disease, and obesity both as cause and effect, many studies have also raised concerns about the long-term consequences of poor glycemic control on the impairment of cognitive function (Biessels et al., 2006; Roy et al., 2015; Matveeva et al. 2019). Cognition refers to largely invisible activities carried out by the human brain to Perceiving, thinking, knowing, reasoning, remembering, analyzing, planning, paying attention, generating and synthesizing ideas, creating, judging, and being aware. Having cognition includes any and all process by which a person becomes aware of his/her situation, needs, goals, and required actions, and uses this information to implement problem solving strategies for optimal living (Borson et al., 2013).

Cognitive impairment (CI) is defined as the degree of cognitive dysfunction that exists between normal ageing and dementia. Subjects can have demonstrable cognitive impairment without crossing the threshold for dementia. This condition has been termed "mild cognitive impairment" (MCI). The MCI syndrome, as an expression of an ascent neurodegenerative disease that may progress

to dementia, is extremely heterogeneous and may coexist with systemic, neurologic, or psychiatric disorders that can cause cognitive deficits (Duara et al., 2013).

The objectives of this study are to improve health of type 2 diabetes mellitus patients in Al-Madinah City in concern of their mental health and improving their CNS function and cognition and to determine the prevalence of mild cognitive impairment among type 2 diabetic patients attending Diabetes Center in Al-Madinah City in 2019. In addition, identifying possible risk factors of mild cognitive impairment among the studied diabetic patients.

2. SUBJECTS & METHODS

The current research is a cross-sectional study. The present study conducted at outpatient clinics in the diabetic center of Al Madinah. This is the largest diabetic center in Al_MadinahAlMunawara region and serves the city and most of the nearby cities. The diabetic patients are attending the center for treatment and follow up. The study was taking about 12 months from the mid 2019 till the mid 2020. All type 2 diabetic patients attending the diabetes center during the period of the study were eligible to be included in the present study but with the following exclusion criteria; diabetics with organ failure, malignancy, autoimmune diseases, any mental disorders or pregnant females, participants who had severe problems of vision, hearing, or speaking, and those were not able to participate actively evaluation, participants who refused to complete the tests, and uneducated and illiterate participants.

Sampling Method

A simple random sample was used in the selection of cases, the selection criteria were done to collect as much as possible risk factors of mild cognitive impairment as much as possible. The visits for selection was done two days per week. Sample size was calculated by Epi-Info software (version 5). Population size of 2619 subjects based on data from information technology department in King Fahd Hospital. Based on the literature review, the size of the studied sample is calculated according to expected frequency of MCI among diabetic patients of 22% and worst acceptable frequency of 16%, confidence level of 95%, and an alpha error of 5%. The calculated sample size was 171, but it was increased to be 200 subjects to overcome the problem of dropout patients and missing data.

Study Tool

The data were collected using two questionnaires. The first one is general and structured questionnaire designed with special emphasis on general demographics and risk factors of MCI like (age, sex, education, occupation, duration of diabetes, living habits, smoking, tea, coffee and physical activity, vitamin supplementation). This questionnaire was validated and adapted from a previous similar by El shamyet al., (2020) in Egypt, and reevaluated by the researcher in the pilot study of the current article (Appendix 1). The second questionnaire is the Montreal Cognitive Assessment (MoCA) was used to assess the cognition among the studied diabetic patients (Appendix 2). This tool is a sensitive, valid and reliable 30- point questionnaire that is used to measure cognitive impairment. It examines functions including registration, attention, calculation, recall, language, ability to follow simple commands and orientation. The maximum score is 30 points, any score greater than or equal to 26 points indicates a normal cognition, below this scores can indicates severe (≤9 points), moderate (10-18 points) or mild (19-24 points) cognitive impairment (Gil et al., 2015). There will be a special form of MoCA test for illiterate participants with the same scoring system. This tool was translated to Arabic and validated by Abdel-Rahman and El-Gaafary (Rahman and El Gaafary 2009). A face to face interview was conducted to fill in the questionnaire.

Data entry and analysis

The data entry and statistical analysis were done using SPSS software, version 22.0, for Windows (SPSS, Inc., Chicago, IL). Data were presented using frequencies, means and standard deviation as appropriate for the studied type 2 diabetic patients (n= 200) according to their sociodemographic characteristics and cognitive impairment level. Then, 48 cases with mild cognitive impairment (MCI) and 118 cases with no cognitive impairment were compared by the studied patients' characteristics; age, sex, marital status, number of children, educational level, occupation, smoking and body mass index (BMI) using chi square tests. Also the study outcome (MCI vs. no cognitive impairment) was compared by the diabetes related factors, vitamin and nutritional intake and physical exercise chi square and independent t tests. P values ≤ 0.05 were used as a level of statistical significance. Finally, multivariate logistic regression analyses were used to calculate the corresponding odds ratio (OR) for the association of mild cognitive impairment with all the studied risk factors among the studied diabetic patients where patients with mild cognitive impairment were used as cases and patients with no cognitive impairment were used as control in the regression analyses.

Pilot Study

The researcher conducted a pilot study on 20 diabetic patients. The participants in the pilot study were not included in the final study because of change and modification in the studied general questionnaire.

Ethical consideration

The permission for the study was obtained by the ethical committee of the MOH. The participation was voluntary and anonymous. All studied diabetic patients gave their informed written consent prior to their inclusion in the study (Appendix 3). Confidentiality and privacy of the collected data were assured, and the data were only used for the research purpose.

3. RESULTS

Frequency of cognitive impairment

The data from 200 diabetic patients (type 2) (142 males and 58 females) were analyzed to assess the prevalence of mild cognitive impairment among them and their associated risk factors. The results of this study are presented in the table 1. It shows the prevalence of cognitive impairment among the studied patients. Of the studied 200 patients there have been 118 (59%) patients showed normal cognitive function. Forty-eight patients (24%) were found to have mild cognitive impairment, 15% showed moderate and 2% showed severe impairment.

Table 1: Frequency distribution of cognitive level among the studied diabetic patients (n= 200)

Cognitive level	N (%)
Normal	118 (59.0)
Mild cognitive impairment	48 (24.0)
Moderate cognitive impairment	30 (15.0)
Severe cognitive impairment	4 (2.0)

The pie chart showed the frequency distribution and percentage of the cognitive impairment among the studied diabetic patients (Figure 1). To assess the associated risk factors of this level of impairment, the subsequent analyses has only included 48 cases with mild cognitive impairment and 118 patients with normal cognition for comparison, while the other cases with moderate and severe impairment were excluded.

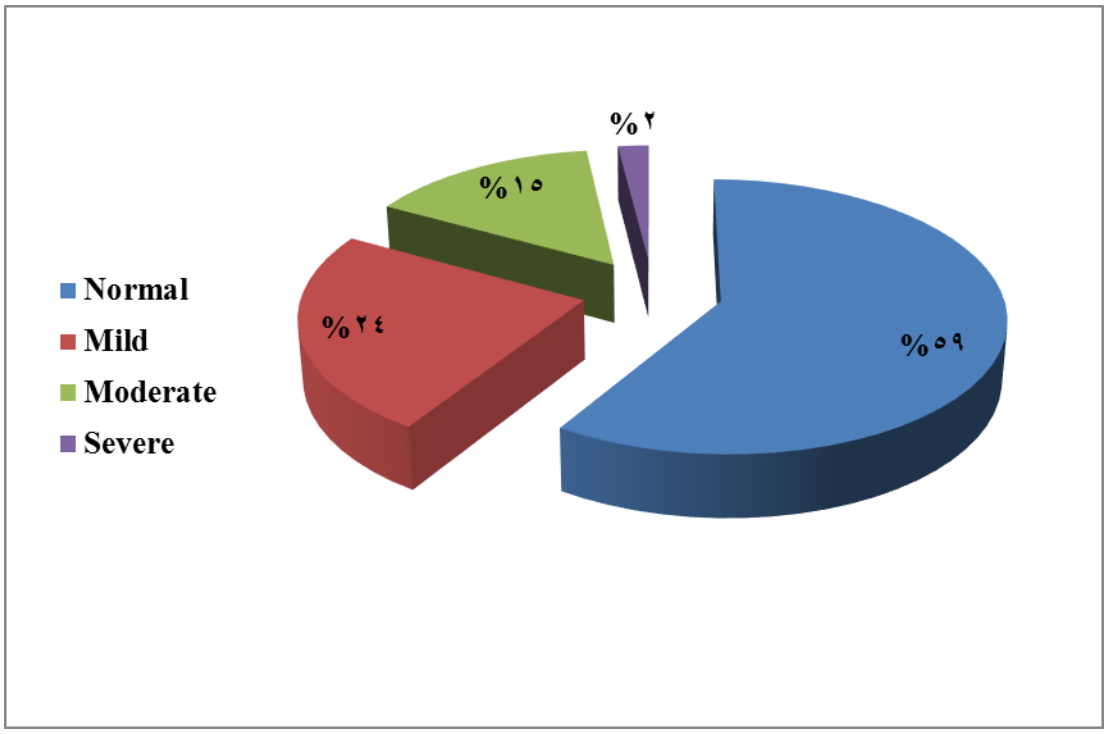

Figure 1: Frequency distribution of cognitive impairment level among the studied diabetic patients (n= 200)

Demographic distribution

Table (2) presents the studied patients' characteristics. The mean age of the studied patients was 52.2 ± 7.5 years with 59% participants aged 50and more years, and male patients were representing 71% of the studied patients. Married patients were 81%, divorced and widow patients were 12 %while single patients were representing only 7%. Thirty-five (28%) of the patients were reported university and higher educational level.

Table 2: Demographic distribution

Items		Mild cognitive impairment (n= 48)	No cognitive impairment (n= 118)	Total	P value
Age in years	**<50**	4 (5.1)	74 (94.9)	78(47.0)	<.0001*
	≥ 50	44 (50.0)	44 (50.0)	88(53.0)	
Patients' sex	**Male**	38 (32.2)	80 (67.8)	118(71.1)	0.3
	Female	10 (20.8)	38 (79.2)	48(28.9)	
Marital status	**Single**	0 (0.0)	14 (100.0)	14(8.4)	0.03*
	Married	46 (33.8)	90 (66.2)	136(81.9)	
	Divorce and widow	2 (12.5)	14 (87.5)	16(9.6)	
Number of children	**< 5**	14 (24.1)	44 (75.9)	58(34.9)	0.48
	≥ 5	34 (31.5)	74 (68.5)	108(65.1)	
Educational level	**Less than university**	36 (34.6)	68 (65.4)	104(62.7)	0.14
	University and higher	12 (19.4)	50 (80.6)	62(37.3)	
Occupation	**Governmental job**	16 (16.3)	82(83.7)	98(59.0)	0.01*
	Private job	4(33.3)	8 (66.7)	12(7.2)	
	Retired	22 (55.0)	18 (45.0)	40(24.1)	
	Do not work	6 (37.5)	10 (62.5)	16(9.6)	

Comorbidities and BMI status

In Table (3), the body mass index of the studied patients showed that 15%normal weight (BMI<25 kg/m2), 35% over weight (BMI 25- < 30 kg/m^2), and 50% were obese with BMI≥ 30kg/m2. The Seventy-nine percent of the studied patients were not smokers, 15% were daily smokers and 6% were occasional smokers.

Table (3) shows the comparison of the studied diabetic patients by presence of mild cognitive impairment and their socio-demographic factors. Significant statistical differences by age, marital status and occupation for the prevalence of mild cognitive were found among the studied patients. The prevalence was more among those aged 50 years and more compared to those <50 years (50% vs. 5.1%). The prevalence was also higher among married patients (33.8%) and those reported private work (33.3%), retired (55%) and those do not work (37.5%).

It also presents the comparison of the studied diabetic patients by presence of mild cognitive impairment and their body mass index and smoking status. Although not statistically significant, the prevalence was higher among overweight (30%) and normal patients compared with obese patients (27.5%). The prevalence was also lower among daily smokers compared with occasional smokers.

Table 3: Comorbidities and drug history in our study

Items	Mild cognitive impairment (n= 48)	No cognitive impairment (n= 118)	Total	P value	Items
Body mass index (kg/m^2)	**< 25**	8 (30.8)	18 (69.2)	26(15.7)	0.95
	25- < 30	18 (30.0)	42 (70.0)	60(36.1)	
	≥ 30	22 (27.5)	58 (62.5)	80(48.2)	
Smoking status	**Never**	40 (30.8)	90 (69.2)	130(78.3)	0.14

	Daily smoker	2 (8.3)	22 (91.7)	24(14.5)	
	Occasional smoker	6 (50.0)	6 (50.0)	12(7.2)	
Duration of diabetes	**< 10**	24 (24.5)	74 (75.5)	98(59.0)	0.28
	≥ 10	24 (35.5)	44 (64.5)	68(41.0)	
Medications for diabetes	**Drugs**	22 (23.9)	70 (76.1)	92(55.4)	0.63
	Injection	16 (34.8)	30 (65.2)	46(27.7)	
	Both	10 (26.3)	18 (73.7)	28(16.9)	
Compliance to diabetic treatment	**Yes**	28 (21.8)	100 (78.2)	128(77.1)	0.02*
	No	20 (52.6)	18 (47.4)	38(22.9)	
HbA1c	**≤ 7**	10 (16.7)	50 (83.3))	60(36.1)	0.03*
	> 7	38 (35.8)	68 (64.2)	106(63.9)	
Family history of diabetes		38 (27.1)	102 (72.9)	140(84.3)	0.4
Heart disease		14 (38.4)	22 (61.6)	36(21.7)	0.29
Eye disease		8 (25.0)	24 (75.0)	32(19.3)	0.67
CNS disease		2 (33.3)	4 (66.7)	6(3.6)	0.87
Foot and hand infections		0 (0.0)	8 (100.0)	8(4.8)	0.25
Hypertension		34 (34.0)	66 (66.0)	100(60.2)	0.04*

A comparison of the studied diabetic patients by presence of mild cognitive impairment and their diabetes related factors. The prevalence of mild cognitive impairment was significantly lower among those patients reported compliance to diabetic medications (21.8%) and those with HbA1c ≤ 7 (16.7%). Although not significant, the prevalence was also lower among patients with duration of diabetes < 10 years (24.5%), taking drugs for diabetes treatment (23.9%), and those reported positive family history of diabetes mellitus (27.1%).

Compared with sedentary life patients and those performing moderate and vigorous exercise, the prevalence was lower among those performing mild exercise like walking and yoga (16.6% vs. 23.8% and 37.1%, respectively), although not significant. The mean duration of exercises per week was more or less similar among the studied patients in both groups.

The risk of mild cognitive impairment was significantly increased by increasing age of the patients. The risk was 18.5 times more among patients aged 50 and more years compared with those aged <50 years. Also, the risk was significantly increased among retired patients (OR= 6.50; 95% CI 1.45-10.55).

On the other hand, however, the risk was decreased among female and divorced and widow patients and among those with university and higher level of education.

The risk of mild cognitive impairment among the studied patients was increased among overweight patients (BMI from 25 to less than 30 kg/m2) and among occasional smokers, although not significant. The risk, however, was insignificantly decreased among patients reported daily smokers with odds ratio of 0.20 (95% CI= 0.04-1.12).

Significant increase in the risk of mild cognitive impairment was found among patients reported no compliance to diabetes treatment (OR= 3.95; 95% CI= 1.47-6.78) and among those with HBA1c > 7 with odds ratio of 2.8095% CI= 1.10-5.23). Although not significant, the risk was also increased among patients with diabetes duration of 10 and more years, patients using injection treatment. The risk, however, was insignificant, among those patients reported positive family history of diabetes mellitus.

Hypertensive patients showed significant increased risk of mild cognitive impairment with odds ratio of 1.9 (95% CI= 1.15-4.56). Also the risk was increased among patients with heart and CNS diseases, although not significant. On the other hand, however, the risk was decreased among those reported foot and hand infections, although not significant.

Effect of vitamin supplementation and dietary intake

Table (4) displays the association of mild cognitive impairment with vitamin and nutritional intake of the studied diabetic patients. The risk of mild cognitive impairment was significantly decreased among patients reported vitamin B6 and B12 intake with odds ratio of 0.30 and 0.65, respectively. Also the risk was reduced by 65% and 63% among patients reported eating fish and eggs of 3 and more times per week with odds ratio of 0.35 and 0.37, respectively. Although not significant, the risk was decreased by 65% among patients reported drinking green tea 3 and more times per day. For other studied nutrients, the risk was increased among patients reported eating meat ≥ 3 times per week, fruits, vegetables and beans <3 times per week, although not significant.

It also shows the association of mild cognitive impairment with performance of physical activity of the studied diabetic patients. Mild physical exercise such as walking and yoga was associated significant risk reduction of mild cognitive impairment by 35% with odds ratio of 0.65 (95% CI= 0.05-3.23) in comparison with sedentary life patients. However, moderate and vigorous physical exercise such as running, hard swimming and bicycling was associated with increased risk (OR= 1.9; 95% CI= 0.87-4.56).

Table 4: Nutritional status and dietary habits in our study

Items		Mild cognitive impairment (n= 48)	No cognitive impairment (n= 118)	Total	P value	Items
Vitamin supplementation	**No**	30 (46.9)	44 (53.1)	74(44.6)		
	B6	10 (15.1)	56 (84.9)	66(39.8)	0.03*	
	B12	8 (30.8)	18 (69.2)	26(15.7)		
Frequency of fish intake/week	**No**	6 (37.5)	10 (62.5)	16(9.6)		
	< 3	28 (41.2)	40 (58.8)	68(41.0)	0.04*	
	≥ 3	14 (17.1)	68 (82.9)	82(49.4)		
Frequency of meat intake/week	**No**	1 (0.50)	22 (99.5)	23(13.9)		
	< 3	9 (36.0)	16 (64.0)	25(15.1)	0.01*	
	≥ 3	38 (32.2)	80 (67.8)	118(71.1)		
Frequency of egg intake/week	**No**	10 (45.5)	12 (55.5)	22(13.3)		
	< 3	6 (75.0)	2 (25.0)	8(4.8)	0.03*	
	≥ 3	32 (23.5)	104 (76.5)	136(81.9)		
Frequency of beans intake/week	**No**	6 (25.0)	18 (75.0)	24(14.5)		
	< 3	6 (42.9)	8 (57.1)	14(8.4)	0.6	
	≥ 3	36 (28.1)	92 (71.9)	128(77.1)		
Frequency of vegetables intake/week	**No**	2 (16.6)	10 (83.4)	12(7.2)		
	< 3	6 (60.0)	4 (40.0)	10(6.0)	0.24	
	≥ 3	40 (27.8)	104 (72.2)	144(86.7)		
Frequency of fruit intake/week	**No**	2 (10.0)	18 (90.0)	20(12.0)		
	< 3	8 (40.0)	12 (60.0)	20(12.0)	0.3	
	≥ 3	38 (30.2)	88 (69.8)	126(75.9)		
Frequency of caffeine drinks intake/day	**No**	4 (14.3)	24 (85.7)	28(16.9)		
	< 3	12 (40.0)	18 (60.0)	30(18.1)	0.3	
	≥ 3	32 (30.6)	76 (69.4)	108(65.1)		
Frequency of green tea drinks intake/day	**No**	34 (37.8)	56 (62.2)	90(54.2)		
	< 3	4 (20.0)	16 (80.0)	20(12.0)	0.15	
	≥ 3	10 (17.9)	46 (82.1)	56(33.7)		
Level of exercise	**Sedentary life**	20 (23.8)	64 (71.2)	84(50.6)		
	Mild exercise	2 (16.6)	10 (83.4)	12(7.2)		
	Moderate and vigorous exercise	26 (37.1)	44 (62.9)	70(42.2)	0.54	
Mean duration of exercise in hour /week*		2.3 ± 2.2	2.1 ± 2.5	2.157±2.413	0.95	

4. DISCUSSION

The results of this study revealed that diabetic patients attending diabetes center in Al- Madinah, Saudi Arabia, have a considerable prevalence of mild cognitive impairment (MCI) reaching up to 24%.

The prevalence of MCI among type 2 diabetic patients showed wide variations in different studies. For example, one population-based study suggested that the prevalence of MCI in diabetic patients was around 28% (Luchsingeret al., 2007), and another study reported the prevalence of MCI in elders was 31.5% (Gorska-Ciebiada et al., 2014). In Egypt, a similar prevalence of MCI was reported among Egyptian type 2 diabetics, and it was 22% (Elshamyet al., 2020). However, a recent Egyptian study on 100 type 2 diabetic patients showed a high prevalence of MCI among the studied diabetic patients, and it reached 34% (Abdellatif et al., 2020).

In Saudi Arabia, the prevalence of MCI on general population ranges between 10 and 20% (Langa and Levine 2014). Regionally, the prevalence of cognitive impairment for both dementia and MCI among Arabic speaking populations are substantially varied and ranges between 4.4 and 32% (Zaitoun et al., 2008). To this moment, there are no published studies in Saudi Arabia, about the prevalence of MCI and dementia and its associated risk factors among type 2 diabetic patients.

The prevalence of MCI in this study showed some significant differences by some of the studied risk factors. The risk of mild cognitive impairment was significantly increased by increasing age of the patients (Petersen et al., 2018).

These results were consistent with the results of many other studies, that advanced age was a risk factor for MCI. In general, the prevalence of MCI was found to be higher in elderly population (Gao et al., 2016).

The present study has also calculated the risk of MCI in association with patient's age and the risk is found to be 18.5 time among patients ≥50 years compared with those aged <50 year.

Other socio-demographic factors found in this study to affect the prevalence and the risk of MCI among the studied diabetic patients were patients' sex, marital status, educational level and occupation. The prevalence and the risk were higher among married patients, private workers and retired and those patients reported less than university educational level. Also, the prevalence and risk was high among overweight and occasional smokers. Age, low level of education, smoking, obesity all considered risk factors for dementia in general adult population (Prince et al., 2013).

Studying the prevalence of MCI among the studied patients in relation to their diabetes related factors showed that the prevalence was significantly lower among those patients reported compliance to diabetic medications (21.8%) and those with HbA1c ≤ 7 (16.7%). Also, a lower prevalence was detected among patients with duration of diabetes < 10 compared with those with ≥ 10 years and the prevalence was more among patients reported injection treatment. These results are consistent with the results of other similar studies conducted among diabetics as well as in general adult population (Prince et al., 2013; Petersen et al., 2018). Control of glycemic status and duration of disease is found as risk factors for developing cognitive dysfunction. In the Diabetes Control and Complications Trial (DCCT) and the Epidemiology of Diabetes Interventions Complications (EDIC) study, diabetic patients who had higher glycosylated hemoglobin levels (HBA1C > 8.8%) showed moderate declines in motor speed and psychomotor efficiency compared to patients who had better glycemic control (HBA1C < 7.4%) (Jacobson et al., 2007). In the present study, the risk of MCI was significantly increased among those patients with HbA1C > 7 with an estimated odds ratio of 2.8 (95% CI= 1.10-5.23).

The prevalence was higher among patients reported injection (Insulin) treatment with a prevalence of MCI was reported to be 34.8%. This result might be attributed to insulin resistance among these patients.

Few longitudinal studies have evaluated this issue, although many cross-sectional studies have confirmed the relationship between insulin resistance and cognitive decline (Young, Mainous, and Carnemolla 2006).

The concomitant medical conditions have also showed significant association with MCI among the studied diabetic patients, particularly among those with cardiovascular diseases and hypertension. Data from Saudi Arabia shows high prevalence MCI among patients with these risk factors (Memishet al., 2014). Among the general adult population, the prevalence of hypertension and hypercholesterolemia is estimated to be 26 and 50%, respectively (Al-Nozhaet al., 2007). The prevalence of hypertension and diabetes in the current study is consistent with the morbidity profile among the elderly population in Saudi Arabia as reported in other studies (Hassanien, Jabloun, and Al-Modeer 2013).

In this study, the prevalence of MCI was 25% among patients with eye diseases. As the most specific microvascular complication of diabetes, diabetic retinopathy shares an overlapped pathophysiology with cognitive decline (Simó, Stitt, and Gardner 2018). Several studies have explored the association of diabetic retinopathy with cognitive impairment, however, their conclusions were conflicting (Ding et al., 2010).

The role of vitamin supplementation and nutrient intake in the prevalence of MCI and its risk effect was also examined in this study. The prevalence of MCI among the studied type 2 diabetic patients was significantly decreased among patients reported vitamin B6 and B12 intake with prevalence of 15.1% and 30.8%, respectively. Also, the prevalence was significantly decreased among patients reported consumption of fish ≥ 3 times per week (17.1%), and eggs ≥ 3 times per-week (23.5%). Among these patients, the risk of MCI was reduced to70% and 35% among patients reported vitamin B6 and B12, respectively.

Also the risk was reduced by 65% and 63% among patients reported to eat fish and eggs of 3 and more times per week. Green tea intake of 3 and more times per day was also associated with risk reduction of 65%.

B vitamins, particularly vitamin B12 and B6, have a role in energy production and metabolism within the central nervous system. B vitamins have also been implicated in the production of nucleic acids and production and maintenance of myelin essential for good neuronal health (Pawlak, Lester, and Babatunde 2014).

Several studies have shown that the diet, which emphasizes the intake of fish, vegetables, fruits, nuts, olive oil, and certain fat ingredients, but less meat, can prevent cognitive functional impairment (Gu 2010). In the present study excess meat intake of ≥ 3 time per week was associated with an increased prevalence of MCI among the studied patients (32.2%) and the risk was 10.5 time among those patients compared with patients reported no meat intake.

A survey conducted by (Ye, Bhupathiraju, and Tucker 2013) and a study by (Loef and Walach 2012) revealed that antioxidants including daily drinking of green tea, vitamins, and folic acid are effective in enhancing memory and cognitive function. Loef and Walach have also reported that simple sugars in fruits and a high glycemic index can decrease temporal lobe and hippocampal volumes, regions that supervise hearing, olfaction, and sensory language, and such factors may also increase the risk for mild cognitive functional impairment. The results of this study in concern with consumption of fruits were consistent with the study of Loef and Walach (Loef and Walach 2012). A cross-sectional survey of 672 participants with normal cognitive function, with their mean age of 79.8 years, used a questionnaire survey to determine the frequency of intake of 128 different foods, and the results revealed a high intake of soybeans, fish, and whole grains. The participants in that study presented with good nutritional status, normal magnetic resonance imaging (MRI) results (based on cortical thickness) as well as more or less normal cognitive function (Huang et al., 2016).

Compared to sedentary life among the studied diabetic patients, the present study results found a decrease in the prevalence of MCI among those performing mild physical activity such walking and yoga. The prevalence was 16.6% and the risk was reduced by 35% among these patients.

Regular exercise when many pathological disease processes likely begin, has been linked to reduced dementia risk and improved cognitive profile in older adults (Huang et al., 2016). Among older adults, those who exercised for at least 30 minutes per day, 5 days per week, for at least 10 years demonstrated lower brain Aβ deposition (using Pittsburgh compound Bon positive emission tomography [PET] scan) (Isaacs et al., 1992). Given its multiple beneficial effects in the brain, regular physical exercise is recommended to help reduce the negative cognitive effects of type 2 diabetes. In general adult population, the benefits of exercise on cognitive function have also been demonstrated in healthy older adults and in adults with cognitive impairment, and so exercise appears to have positive implications for the reduction of dementia risk (Hu et al., 2015).

This study has its own limitations. Being the design was cross-sectional, in which both cause and effect are measured at the same time; therefore, the causality of association could not be confirmed. Although the study was conducted in the largest Diabetic Center in Al-Madinah city that serves large number of population in AlMadinah and nearby regions, the study was conducted in only one city, and so it is difficult to generalize about the study finding to all diabetic patients in the Kingdom. However, the main scope of this study was to probe this important public health issue and to add to Saudi literature.

5. CONCLUSION

The current study showed a considerable prevalence of MCI among type 2 diabetic patients in Al-Madinah Al-Munawara, Saudi Arabia. Some factors appeared to be at a higher risk of MCI and was found to increase the prevalence among the studied diabetic patients. patients' age, sex, marital status, educational level and occupation are amongst the socio-demographic factors. Also, the diabetes duration, compliance to treatment, HbA1c level and type of medication as well as the associated heart disease and hypertension were included.

Abbreviation list:

95% CI: Confidence interval
BMI: Body mass index
CI: Cognitive impairment
DCCT: Diabetes Control and Complications Trial
DM: Diabetes mellitus
HBA1c: Glycated hemoglobin
MCI: Mild cognitive impairment
MoCA: Montreal Cognitive Assessment

OR: Odd ratio
PET: Positive Emission Tomography
WHO: World Health Organization

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Author Contributions

AJ was responsible for study design, data collection and manuscript writing. KAS is the guarantor of this study.

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Conflict of interest

The authors declare that there are no conflicts of interests.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Ethical approval

The study was approved by the Medical Ethics Committee of Institutional Review Board, General Directorate of Health Affairs in Modino H-03-M-084 with no IRB 363.

Data and materials availability

All data associated with this study are available upon request to the corresponding author.

Peer-review

External peer-review was done through double-blind method.

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